Big Data and Computing Visions

www.bidacv.com

Big. Data. Comp. Vis. Vol. 4, No. 2 (2024) 135–145.

Paper Type: Original Article

Enhanced Airport Security Screening Under Fermatean Probabilistic Hesitant Fuzzy Hybrid Aggregation Information

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Citation:

Received: 14 March 2023 Revised: 21 May 2023 Accepted:02/08/2023	Iqba, W., Ashraf, Sh., Akram, M., & Hameed, M., (2024). Enhanced Airport Security Screening Under Fermatean Probabilistic Hesitant Fuzzy Hybrid Aggregation Information. *Big data and computing visions*,*4*(2), 135-145.

Abstract

Optimizing airport security screening processes is imperative in the modern age, ensuring a delicate balance between stringent security measures and efficient, seamless travel experiences for passengers. This research presents an innovative paradigm for decision-making that optimizes airport security screening procedures. By utilizing sophisticated fuzzy concepts, particularly Fermatean Probabilistic Hesitant Fuzzy Sets, the research presents new hybrid aggregation techniques known as Fermatean Probabilistic Hesitant Hybrid Weighted Averaging FePHHWA and Hybrid Weighted Geometric FePHHWG. These procedures are intended to improve the decision-making process by providing a thorough method of addressing the intricacies of security screening. In addition to showcasing the flexibility and effectiveness of Fermatean Probabilistic Hesitant Fuzzy Sets, the suggested technique creates a strong foundation for resolving issues with airport security screening by utilizing the recently developed hybrid aggregation processes.

Keywords: Optimization, Hesitant Fuzzy Sets, Hybrid Aggregation, FePHHWA, Decision-Making.

1|Introduction

Improving airport security screening procedures is essential to guaranteeing the effectiveness and safety of air transport.It is critical to use cutting-edge approaches that expedite screening processes without sacrificing efficacy in the face of changing security threats. Making use of cutting-edge technologies like hybrid

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https://doi.org/10.22105/bdcv.2024.481526.1207

aggregation procedures and Fermatean Hesitant Probabilistic Fuzzy logic presents a viable way to improve security screening decision-making. Airports may strike a balance between thoroughness and efficiency by using these cutting-edge methods, reducing traveler delays while upholding a strong security framework. In addition to enhancing general airport security, this optimization helps make travel easier and more seamless for both passengers and aviation staff.

Improving airport security screening procedures is closely related to decision-making and is a vital component of guaranteeing efficient security protocols. In this situation, the application of cutting-edge technologies like fuzzy logic acts as a tool for strategic decision-making. It entails the methodical study of intricate and ambiguous data to enable security professionals to make deft judgments instantly. The use of these approaches improves the process of making decisions by offering a thorough and sophisticated comprehension of possible security risks. As a result, it helps airports to combine operational effectiveness with comprehensive security inspections, highlighting the critical role that decision-making plays in attaining optimum airport security screening procedures.

As a key technique for handling uncertainty in Multiple Attribute Decision Making (MADM), Zadeh invented Fuzzy Sets (FS) in 1965. Positive grades of components from a universal set are used to express the FS; negative grades are not used. However, a number of FS notation modifications have appeared in domains including engineering, medical diagnostics, and decision-making as a result of worries over the validity of these sets. The challenges of uncertainty have been effectively addressed by extensions such as Intuitionistic FSs [1], Pythagorean FSs [2], and Fermatean FSs (FeFSs) [3], which under certain circumstances take into account both positive and negative grades. FeFSs, in particular, perform better in decision-making situations [4] to [7] than Pythagorean and intuitionistic FSs in managing a wider range of uncertainty and conveying imprecise human judgments. Researchers have successfully applied fuzzy logic and its advanced concepts to solve numerous decision-making practical scenarios, particularly in emergency scenarios [8], [9]. An example is the cleaner production evaluation in gold mines as explored in [10].

The utilization of Hesitant Fuzzy Sets (HFS) [20] instead of standard FS has significantly improved MADM, particularly in handling ambiguity stemming from expert opinions. A thorough examination and future outlook on HFSs were conducted in a study by [21], demonstrating their efficiency in minimizing uncertainty by enhancing the elicitation of expert preferences and serving as a more adaptable and flexible preference structure. The increased capabilities of FeFSs have been acknowledged by several research that have adopted FeFS approaches to address complex problems in MADM. Notably, in [11], the WASPAS approach was expanded inside a FeFS framework, and in [12], information measures were included. In order to assess facilities in light of the COVID-19 pandemic, [13] used FFS aggregating functions. FeFSs were also used by [14] to control parameter uncertainty in capital budgeting. By using a scoring function and FeFS settings, [15] was able to solve fuzzy transportation issues successfully. In [16], FeFSs broadened the TOPSIS method's uses. [17] proposed Einstein averaging operators and used TOPSIS with FeFSs to find the best sanitizer in the fight against COVID-19. Additionally, to improve laboratory selection for COVID-19 testing, [18] combined SAW, ARAS, and VIKOR inside a FeFS framework. All of these research highlight how flexible and useful FeFSs are in a range of decision-making situations.

Hesitant Fuzzy Sets (HFS) was presented in [19],discussed further in [20] and [24] discussed generalized hesitant fuzzy sets. In a revolutionary investigation, [21] explored Intuitionistic Hesitant Fuzzy Sets, which are created by combining IFS with HFS. Pythagorean Hesitant Fuzzy Sets, a further expansion suggested by [22], combine HFS with Pythagorean FS. Then, in a medical case study, [23] presented Fermatean Hesitant Fuzzy Sets (FeHFS), a combination of HFS and FFS. Based on this, Pythagorean Probabilistic Hesitant Fuzzy Sets were introduced by [25], which is improved further in [26] and [27]. These sets have equal degrees of positive and negative hesitant adhesions, with the requirement that the square sum of these degrees be less than or equal to one.

Given the more general nature of Fermatean Fuzzy Sets (FeFS) compared to Pythagorean FS, a new concept, Fermatean Probabilistic Hesitant Fuzzy Sets (FePHFSs) [28], is proposed. FePHFSs require that the cube total of the hesitant positive and negative grades be less than or equal to one. The constraints of Pythagorean Probabilistic Hesitant FS, which restricts the square sum of positive and negative hesitant grades to be less than or equal to one, served as the model for this restriction. Therefore, FePHFSs aim to effectively handle expert uncertainty while accounting for the likelihood of each factor occurring.

The paper is structured as follows: The introductory section provides an overview of the study. In Section 2, we delve into fundamental concepts essential for comprehending the subsequent content. Section 3 introduces

a hybrid aggregation operators in FePHFS. Following that, Section 4 presents and discusses a case study on enhancing airport screening. Finally, Section 5 serves as the conclusion, summarizing the key findings of the article.

2|Preliminaries

In this part, we'll go into the significance and impact of the main concepts that were considered essential to developing this piece of literature. [28]
Assume $\Im$ be a universal set. Then a FePHFS on $\Im$ is given as:

$$\aleph = \{\varepsilon, \mho_{\flat_{\bullet}}(\varepsilon)/\kappa, \nu_{\flat_{\bullet}}(\varepsilon)/\kappa^{\bullet} | \varepsilon \in \aleph\} \tag{1}$$

where $\varepsilon \in \aleph, \mho_{\flat_{\bullet}}(\varepsilon)$ and $\nu_{\flat_{\bullet}}(\varepsilon)$ are sets of certain values in [0,1]. $\mho_{\flat_{\bullet}}(\varepsilon)\kappa$ and $\nu_{\flat_{\bullet}}(\varepsilon)/\kappa^{\bullet}$ known as probable positive and negative grades respectively, and $\kappa, \kappa^{\bullet}$ shows the probabilities of grades.
Moreover, $0 \leq \flat_{\bullet_i}, \zeta_{\bullet_j} \leq 1$ and $0 \leq \kappa_i, \kappa_j^{\bullet} \leq 1, \sum_{i=1}^{\curlywedge} \kappa_i \leq 1 \& \sum_{j=1}^{\curlywedge} \kappa_i^{\bullet} \leq 1$ with $\curlywedge$ being positive integer to show the cardinality of FePHFS. It is necessary to satisfy the criteria below, beyond all this.

$$\left(min\left(\mho_{\flat_{\bullet}}(\varepsilon)\right)\right)^3 + \left(max\left(\nu_{\flat_{\bullet}}(\varepsilon)\right)\right)^3 \leq 1, \left(max\left(\mho_{\flat_{\bullet}}(\varepsilon)\right)\right)^3 + \left(min\left(\nu_{\flat_{\bullet}}(\varepsilon)\right)\right)^3 \leq 1 \tag{2}$$

The Fermatean probabilistic hesitant fuzzy number (FPHFN) is represented by the pair $\left(\mho_{\flat_{\bullet_*}}(\varepsilon)/\kappa_*, \nu_{\flat_{\bullet_*}}(\varepsilon)/\kappa_*^{\bullet}\right)$.
[28] Assume $\aleph_1 = \left(\mho_{\flat_{\bullet_1}}(\varepsilon)/\kappa_1, \nu_{\flat_{\bullet_1}}(\varepsilon)/\kappa_1^{\bullet}\right)$ and $\aleph_2 = \left(\mho_{\flat_{\bullet_2}}(\varepsilon)/\kappa_2, \nu_{\flat_{\bullet_2}}(\varepsilon)/\kappa_2^{\bullet}\right)$ be FePHFNs. The basic operational laws are given as:

$$\mathbf{1}.\ \aleph_1 \cup \aleph_2 = \left\{ \bigcup_{\substack{\flat_{\bullet_1} \in \mho_{\flat_{\bullet_1}}, \kappa_1 \in \kappa \\ \flat_{\bullet_2} \in \mho_{\flat_{\bullet_2}}, \kappa_2 \in \kappa}} \left(max\left(\flat_{\bullet_1}/\kappa_1, \flat_{\bullet_2}/\kappa_2\right)\right), \bigcup_{\substack{\zeta_{\bullet_1} \in \nu_{\flat_{\bullet_1}}, \kappa_1^{\bullet} \in \kappa^{\bullet} \\ \zeta_{\bullet_2} \in \nu_{\zeta_{\bullet_2}}, \kappa_2^{\bullet} \in \kappa^{\bullet}}} \left(min\left(\zeta_{\bullet_1}/\kappa_1^{\bullet}, \zeta_{\bullet_2}/\kappa_2^{\bullet}\right)\right)\right\}.$$

$$\mathbf{2}.\ \aleph_1 \cap \aleph_2 = \left\{ \bigcap_{\substack{\flat_{\bullet_1} \in \mho_{\flat_{\bullet_1}}, \kappa_1 \in \kappa \\ \flat_{\bullet_2} \in \mho_{\flat_{\bullet_2}}, \kappa_2 \in \kappa}} \left(min\left(\flat_{\bullet_1}/\kappa_1, \flat_{\bullet_2}/\kappa_2\right)\right), \bigcup_{\substack{\zeta_{\bullet_1} \in \nu_{\flat_{\bullet_1}}, \kappa_1^{\bullet} \in \kappa^{\bullet} \\ \zeta_{\bullet_2} \in \nu_{\zeta_{\bullet_2}}, \kappa_2^{\bullet} \in \kappa^{\bullet}}} \left(max\left(\zeta_{\bullet_1}/\kappa_1^{\bullet}, \zeta_{\bullet_2}/\kappa_2^{\bullet}\right)\right)\right\}.$$

$$\mathbf{3}.\ \text{If } \aleph_2 = \left(\mho_{\flat_{\bullet_2}}(\varepsilon)/\kappa_2, \nu_{\flat_{\bullet_2}}(\varepsilon)/\kappa_2^{\bullet}\right), \text{ then } \aleph_2^c = \left(\nu_{\flat_{\bullet_2}}(\varepsilon)/\kappa_2^{\bullet}, \mho_{\flat_{\bullet_2}}(\varepsilon)/\kappa_2\right).$$

Assume $\aleph_1 = \left(\mho_{\flat_{\bullet_1}}(\varepsilon)/\kappa_1, \nu_{\flat_{\bullet_1}}(\varepsilon)/\kappa_1^{\bullet}\right)$ and $\aleph_2 = \left(\mho_{\flat_{\bullet_2}}(\varepsilon)/\kappa_2, \nu_{\flat_{\bullet_2}}(\varepsilon)/\kappa_2^{\bullet}\right)$ be FePHFNs and $\curlywedge > 0$, then their operations can be written as follows:

$$\mathbf{1}.\ \aleph_1 \oplus \aleph_2 = \left\{ \bigcup_{\substack{\flat_{\bullet_1} \in \mho_{\flat_{\bullet_1}}, \kappa_1 \in \kappa \\ \flat_{\bullet_2} \in \mho_{\flat_{\bullet_2}}, \kappa_2 \in \kappa}} \left(\sqrt[3]{\flat_{\bullet_1}^3 + \flat_{\bullet_2}^3 - \flat_{\bullet_1}^3 \flat_{\bullet_2}^3}/\kappa_1\kappa_2\right), \bigcup_{\substack{\zeta_{\bullet_1} \in \nu_{\flat_{\bullet_1}}, \kappa_1^{\bullet} \in \kappa^{\bullet} \\ \zeta_{\bullet_2} \in \nu_{\zeta_{\bullet_2}}, \kappa_2^{\bullet} \in \kappa^{\bullet}}} \left(\zeta_{\bullet_1}\zeta_{\bullet_2}/\kappa_1^{\bullet}\kappa_2^{\bullet}\right)\right\}.$$

$$\mathbf{2}.\ \aleph_1 \otimes \aleph_2 = \left\{ \bigcup_{\substack{\flat_{\bullet_1} \in \mho_{\flat_{\bullet_1}}, \kappa_1 \in \kappa \\ \flat_{\bullet_2} \in \mho_{\flat_{\bullet_2}}, \kappa_2 \in \kappa}} \left(\flat_{\bullet_1}\flat_{\bullet_2}/\kappa_1\kappa_2\right), \bigcup_{\substack{\zeta_{\bullet_1} \in \nu_{\flat_{\bullet_1}}, \kappa_1^{\bullet} \in \kappa^{\bullet} \\ \zeta_{\bullet_2} \in \nu_{\zeta_{\bullet_2}}, \kappa_2^{\bullet} \in \kappa^{\bullet}}} \left(\sqrt[3]{\zeta_{\bullet_1}^3 + \zeta_{\bullet_2}^3 - \zeta_{\bullet_1}^3\zeta_{\bullet_2}^3}/\kappa_1^{\bullet}\kappa_2^{\bullet})\right)\right\}.$$

$$\mathbf{3}.\ \curlywedge\aleph_2 = \left\{ \bigcup_{\flat_{\bullet_2} \in \mho_{\flat_{\bullet_2}}, \kappa_2 \in \kappa} \left(\sqrt[3]{1 - \left(1 - \flat_{\bullet_2}^3\right)^{\curlywedge}}/\kappa_2\right) \bigcup_{\zeta_{\bullet_2} \in \nu_{\flat_{\bullet_2}}, \kappa_2^{\bullet} \in \kappa^{\bullet}} \left(\zeta_{\bullet_2}^{\curlywedge}/\kappa_2^{\bullet}\right)\right\}.$$

$$\mathbf{4}.\ \aleph_2^{\curlywedge} = \left\{ \bigcup_{\flat_{\bullet_2} \in \mho_{\flat_{\bullet_2}}, \kappa_2 \in \kappa} \left(\flat_{\bullet_2}^{\curlywedge}/\kappa_2\right) \bigcup_{\zeta_{\bullet_2} \in \nu_{\flat_{\bullet_2}}, \kappa_2^{\bullet} \in \kappa^{\bullet}} \left(\sqrt[3]{1 - \left(1 - \zeta_{\bullet_2}^3\right)^{\curlywedge}}/\kappa_2^{\bullet}\right)\right\}.$$

A score function for any FePHFN $\aleph = \left(\mho_{\flat_{\bullet_*}}(\varepsilon)/\kappa_*, \nu_{\flat_{\bullet_*}}(\varepsilon)/\kappa_*^{\bullet}\right)$ is given as:

$$\Upsilon(\aleph) = \left(\frac{1}{\blacksquare_{\aleph}} \sum_{\flat_{\bullet_i} \in \mho_{\flat_{\bullet_i}}, \kappa_i \in \kappa} \left(\flat_{\bullet_i}\kappa_i\right)\right)^3 - \left(\frac{1}{\blacklozenge_{\aleph}} \sum_{\zeta_{\bullet_i} \in \nu_{\flat_{\bullet_i}}, \kappa_i^{\bullet} \in \kappa^{\bullet}} \left(\zeta_{\bullet_i}\kappa_i^{\bullet}\right)\right)^3 \tag{3}$$

where $\blacksquare_{\aleph}$ and $\blacklozenge_{\aleph}$ shows the number of elements in $\mho_{\flat_{\bullet_i}}$ and $\nu_{\flat_{\bullet_i}}$, respectively. An accuracy function for any FePHFN $\aleph = \left(\mho_{\flat_{\bullet_*}}(\varepsilon)/\kappa_*, \nu_{\flat_{\bullet_*}}(\varepsilon)/\kappa_*^{\bullet}\right)$ is given as:

$$\nabla(\aleph) = \left(\frac{1}{\blacksquare_{\aleph}} \sum_{\flat_{\bullet_i} \in \mho_{\flat_{\bullet_i}}, \kappa_i \in \kappa} \left(\flat_{\bullet_i} \kappa_i\right)\right)^3 + \left(\frac{1}{\blacklozenge_{\aleph}} \sum_{\zeta_{\bullet_i} \in \nu_{\flat_{\bullet_i}}, \kappa_i^{\bullet} \in \kappa^{\bullet}} \left(\zeta_{\bullet_i} \kappa_i^{\bullet}\right)\right)^3 \tag{4}$$

where $\blacksquare_{\aleph}$ and $\blacklozenge_{\aleph}$ shows the number of elements in $\mho_{\flat_{\bullet_i}}$ and $\nu_{\flat_{\bullet_i}}$, respectively. Assume $\aleph_1 = \left(\mho_{\flat_{\bullet_1}}(\varepsilon)/\kappa_1, \nu_{\flat_{\bullet_1}}(\varepsilon)/\kappa_1^{\bullet}\right)$ and $\aleph_2 = \left(\mho_{\flat_{\bullet_2}}(\varepsilon)/\kappa_2, \nu_{\flat_{\bullet_2}}(\varepsilon)/\kappa_2^{\bullet}\right)$ be FePHFNs.

(1) $\Upsilon(\aleph_1) > \Upsilon(\aleph_2) \Rightarrow \aleph_1 > \aleph_2$.

(2) $\Upsilon(\aleph_1) < \Upsilon(\aleph_2) \Rightarrow \aleph_1 < \aleph_2$.

(3) If $\Upsilon(\aleph_1) = \Upsilon(\aleph_2)$, then go for accuracy:

- $\nabla(\aleph_1) > \nabla(\aleph_2) \Rightarrow \aleph_1 > \aleph_2$.
- $\nabla(\aleph_1) < \nabla(\aleph_2) \Rightarrow \aleph_1 < \aleph_2$.
- $\nabla(\aleph_1) = \nabla(\aleph_2) \Rightarrow \aleph_1 \approx \aleph_2$.

Assume $\beta_i = \left(\mho_{\flat_{\bullet_i}}/\kappa_i, \nu_{\flat_{\bullet_i}}/\kappa_i^{\bullet}\right)(i = 1, 2, ..., \ell)$ be any collection of FePHFNs and Fermatean Probabilistic Hesitant Fuzzy Weighted Average (FePHFWA):FePHFN$\ell \rightarrow$ FePHFN. Then the FePHFWA operator is given as:

$$\begin{aligned} FePHWA(\beta_1, \beta_2, ..., \beta_\ell) &= \Lambda_1\aleph_1 \oplus \Lambda_2\aleph_2 \oplus .... \oplus \Lambda_\ell\beta_\ell. \\ &= \sum_{i=1}^{\ell} \Lambda_i\aleph_i. \end{aligned} \tag{5}$$

Here, $\Lambda = (\Lambda_1, \Lambda_2, ..., \Lambda_\ell)$ are the weights and $\Lambda_i \geq 0, \sum_{i=1}^{\ell} \Lambda_i = 1$. Assume $\beta_i = \left(\mho_{\flat_{\bullet_i}}/\kappa_i, \nu_{\flat_{\bullet_i}}/\kappa_i^{\bullet}\right)(i = 1, 2, ..., \ell)$ be any collection of FePHFNs. Then, the aggregation result obtained by using FePHFWA is as follows:

FePHWA$(\beta_1, \beta_2, ..., \beta_\ell) =$

$$\left\{ \bigcup_{\flat_{\bullet_i} \in \mho_{\flat_{\bullet_i}}, \kappa_i \in \kappa} \sqrt[3]{1 - \prod_{i=1}^{\ell} \left(1 - (\flat_{\bullet_i})^3\right)^{\Lambda}} \Big/ \prod_{i=1}^{\ell} \kappa_i, \bigcup_{\zeta_{\bullet_i} \in \nu_{\flat_{\bullet_i}}, \kappa_i^{\bullet} \in \kappa^{\bullet}} \prod_{i=1}^{\ell} (\zeta_{\bullet_2})^{\Lambda} \Big/ \prod_{i=1}^{\ell} \kappa_i^{\bullet} \right\}. \tag{6}$$

Assume $\beta_i = \left(\mho_{\flat_{\bullet_i}}/\kappa_i, \nu_{\flat_{\bullet_i}}/\kappa_i^{\bullet}\right)(i = 1, 2, ..., \ell)$ be any collection of FePHFNs and Fermatean Probabilistic Hesitant Fuzzy Weighted Geometric (FePHFWG):FePHFN$\ell \rightarrow$ FePHFN. Then the FePHFWG operator is given as:

$$\begin{aligned} FePHWG(\beta_1, \beta_2, ..., \beta_\ell) &= \Lambda_1\aleph_1 \otimes \Lambda_2\aleph_2 \otimes .... \otimes \Lambda_\ell\beta_\ell. \\ &= \prod_{i=1}^{\ell} \Lambda_i\aleph_i. \end{aligned} \tag{7}$$

Here, $\Lambda = (\Lambda_1, \Lambda_2, ..., \Lambda_\ell)$ are the weights and $\Lambda_i \geq 0, \sum_{i=1}^{\ell} \Lambda_i = 1$. Assume $\beta_i = \left(\mho_{\flat_{\bullet_i}}/\kappa_i, \nu_{\flat_{\bullet_i}}/\kappa_i^{\bullet}\right)(i = 1, 2, ..., \ell)$ be any collection of FePHFNs. Then, the aggregation result obtained by using FePHFWG is as follows:

FePHWG$(\beta_1, \beta_2, ..., \beta_\ell) =$

$$\left\{ \bigcup_{\flat_{\bullet_i} \in \mho_{\flat_{\bullet_i}}, \kappa_i \in \kappa} \prod_{i=1}^{\ell} (\flat_{\bullet_2})^{\Lambda} \Big/ \prod_{i=1}^{\ell} \kappa_i, \bigcup_{\zeta_{\bullet_i} \in \nu_{\flat_{\bullet_i}}, \kappa_i^{\bullet} \in \kappa^{\bullet}} \sqrt[3]{1 - \prod_{i=1}^{\ell} \left(1 - (\zeta_{\bullet_i})^3\right)^{\Lambda}} \Big/ \prod_{i=1}^{\ell} \kappa_i^{\bullet} \right\}. \tag{8}$$

3|Hybrid Aggregation Operations

In this part, we will formulate aggregation techniques that use a given score function to produce Fermatean Probabilistic Hesitant Fuzzy Hybrid Aggregation Operations. With decision information given in the form of Fermatean Probabilistic Hesitant Fuzzy Numbers (FePHFNs), the MADM problem is intended to be addressed. Assume $\beta_i = \left(\mho_{\flat_{\bullet_i}}/\kappa_i, \nu_{\flat_{\bullet_i}}/\kappa_i^{\bullet}\right)(i = 1, 2, ..., \ell)$ be any collection of FePHFNs and Fermatean Probabilistic Hesitant Fuzzy Hybrid Weighted Average (FePHFWA):FePHFN$\ell \rightarrow$ FePHFN. Then the FePHFHWA operator is given as:

$$\begin{aligned} FePHHWA(\beta_1, \beta_2, ..., \beta_\ell) &= \Lambda_1 \aleph_1 \oplus \Lambda_2 \aleph_2 \oplus .... \oplus \Lambda_\ell \beta_\ell. \\ &= \sum_{i=1}^{\ell} \Lambda_i \aleph_{\varphi(i)}. \end{aligned} \tag{9}$$

Here, $\Lambda = (\Lambda_1, \Lambda_2, ..., \Lambda_\ell)$ are the weights and $\Lambda_i \geq 0, \sum_{i=1}^{\ell} \Lambda_i = 1$. Also $\varphi(i)$ is the permutation as $(\varphi(1), \varphi(2), ..., \varphi(k))$. Assume $\beta_i = \left(\mho_{\flat_{\bullet_i}}/\kappa_i, \nu_{\flat_{\bullet_i}}/\kappa_i^{\bullet}\right)(i = 1, 2, ..., \ell)$ be any collection of FePHFNs. Then, the aggregation result obtained by using FePHFHWA is as follows:

FePHHWA$(\beta_1, \beta_2, ..., \beta_\ell) =$

$$\left\{ \bigcup_{\flat_{\bullet_{\varphi(i)}} \in \mho_{\flat_{\bullet_i}}, \kappa_{\varphi(i)} \in \kappa} \sqrt[3]{1 - \prod_{i=1}^{\ell} \left(1 - \left(\flat'_{\varphi(i)}\right)^3\right)^{\Lambda}} \Big/ \prod_{i=1}^{\ell} \kappa'_{\varphi(i)}, \bigcup_{\zeta_{\varphi(i)} \in \nu_{\flat_{\bullet_i}}, \kappa^{\bullet}_{\varphi(i)} \in \kappa^{\bullet}} \prod_{i=1}^{\ell} \left(\zeta'_{\varphi(i)}\right)^{\Lambda} \Big/ \prod_{i=1}^{\ell} \left(\kappa^{\bullet}\right)'_{\varphi(i)} \right\}. \tag{10}$$

Proof: We'll use induction method to prove this theorem.
Step 1: For $\ell = 2$, we have $\beta_1 = \left(\mho_{\flat_{\bullet_1}}/\kappa_1, \nu_{\flat_{\bullet_1}}/\kappa_1^{\bullet}\right)$ and $\beta_2 = \left(\mho_{\flat_{\bullet_2}}/\kappa_2, \nu_{\flat_{\bullet_2}}/\kappa_2^{\bullet}\right)$, using the defined operation;

$$\Lambda_1 \aleph_1 \oplus \Lambda_2 \aleph_2 =$$

$$\left(\bigcup_{\flat_{\bullet_{\varphi(1)}} \in \mho_{\flat_{\bullet_1}}, \kappa_{\varphi(1)} \in \kappa} \sqrt[3]{1 - \left(1 - \left(\flat'_{\varphi(1)}\right)^3\right)^{\Lambda_1}} / \kappa'_{\varphi(1)}, \bigcup_{\zeta_{\varphi(1)} \in \nu_{\flat_{\bullet_1}}, \kappa^{\bullet}_{\varphi(1)} \in \kappa^{\bullet}} \left(\zeta'_{\varphi(1)}\right)^{\Lambda_1} / \prod_{i=1}^{2} \left(\kappa^{\bullet}\right)'_{\varphi(1)} \right) \oplus$$
$$\left(\bigcup_{\flat_{\bullet_{\varphi(2)}} \in \mho_{\flat_{\bullet_2}}, \kappa_{\varphi(2)} \in \kappa} \sqrt[3]{1 - \left(1 - \left(\flat'_{\varphi(2)}\right)^3\right)^{\Lambda_2}} / \kappa'_{\varphi(2)}, \bigcup_{\zeta_{\varphi(2)} \in \nu_{\flat_{\bullet_2}}, \kappa^{\bullet}_{\varphi(2)} \in \kappa^{\bullet}} \left(\zeta'_{\varphi(2)}\right)^{\Lambda_2} / \left(\kappa^{\bullet}\right)'_{\varphi(2)} \right).$$

$$= \left(\begin{array}{c} \bigcup_{\substack{\flat_{\bullet_{\varphi(1)}} \in \mho_{\flat_{\bullet_1}}, \kappa_{\varphi(1)} \in \kappa \\ \flat_{\bullet_{\varphi(2)}} \in \mho_{\flat_{\bullet_2}}, \kappa_{\varphi(2)} \in \kappa}} \sqrt[3]{1 - \left(1 - \left(\flat'_{\varphi(1)}\right)^3\right)^{\Lambda_1} + 1 - \left(1 - \left(\flat'_{\varphi(2)}\right)^3\right)^{\Lambda_2} - \left(1 - \left(1 - \left(\flat'_{\varphi(1)}\right)^3\right)^{\Lambda_1}\right)\left(1 - \left(1 - \left(\flat'_{\varphi(2)}\right)^3\right)^{\Lambda_2}\right)} / \kappa'_{\varphi(1)} \kappa'_{\varphi(2)}, \\ \bigcup_{\substack{\zeta_{\varphi(1)} \in \nu_{\flat_{\bullet_1}}, \kappa^{\bullet}_{\varphi(1)} \in \kappa^{\bullet} \\ \zeta_{\varphi(2)} \in \nu_{\flat_{\bullet_2}}, \kappa^{\bullet}_{\varphi(2)} \in \kappa^{\bullet}}} \left(\zeta'_{\varphi(1)}\right)^{\Lambda_1} \left(\zeta'_{\varphi(2)}\right)^{\Lambda_2} / \left(\kappa^{\bullet}\right)'_{\varphi(1)} \left(\kappa^{\bullet}\right)'_{\varphi(2)} \end{array} \right)$$

$$= \left(\begin{array}{c} \bigcup_{\substack{\flat_{\bullet_{\varphi(1)}} \in \mho_{\flat_{\bullet_1}}, \kappa_{\varphi(1)} \in \kappa \\ \flat_{\bullet_{\varphi(2)}} \in \mho_{\flat_{\bullet_2}}, \kappa_{\varphi(2)} \in \kappa}} \sqrt[3]{1 - \left(1 - \left(\flat'_{\varphi(1)}\right)^3\right)^{\Lambda_1} \left(\left(\flat'_{\varphi(1)}\right)^3\right)^{\Lambda_1}} / \kappa'_{\varphi(1)} \kappa'_{\varphi(2)}, \\ \bigcup_{\substack{\zeta_{\varphi(1)} \in \nu_{\flat_{\bullet_1}}, \kappa^{\bullet}_{\varphi(1)} \in \kappa^{\bullet} \\ \zeta_{\varphi(2)} \in \nu_{\flat_{\bullet_2}}, \kappa^{\bullet}_{\varphi(2)} \in \kappa^{\bullet}}} \left(\zeta'_{\varphi(1)}\right)^{\Lambda_1} \left(\zeta'_{\varphi(2)}\right)^{\Lambda_2} / \left(\kappa^{\bullet}\right)'_{\varphi(1)} \left(\kappa^{\bullet}\right)'_{\varphi(2)} \end{array} \right)$$

$$= \left(\begin{array}{c} \bigcup_{\substack{\flat_{\bullet_{\varphi(1)}} \in \mho_{\flat_{\bullet_1}}, \kappa_{\varphi(1)} \in \kappa \\ \flat_{\bullet_{\varphi(2)}} \in \mho_{\flat_{\bullet_2}}, \kappa_{\varphi(2)} \in \kappa}} \sqrt[3]{1 - \prod_{i=1}^{2} \left(1 - \left(\flat'_{\varphi(i)}\right)^3\right)^{\Lambda}} / \prod_{i=1}^{2} \kappa'_{\varphi(i)}, \\ \bigcup_{\substack{\zeta_{\varphi(1)} \in \nu_{\flat_{\bullet_1}}, \kappa^{\bullet}_{\varphi(1)} \in \kappa^{\bullet} \\ \zeta_{\varphi(2)} \in \nu_{\flat_{\bullet_2}}, \kappa^{\bullet}_{\varphi(2)} \in \kappa^{\bullet}}} \prod_{i=1}^{2} \left(\zeta'_{\varphi(i)}\right)^{\Lambda_1} / \prod_{i=1}^{2} \left(\kappa^{\bullet}\right)'_{\varphi(i)} \end{array} \right)$$

thus, it is true for $\ell = 2$.
Step 2: Let, the result holds for $\ell = q$.

$$FePHHWA(\beta_1, \beta_2, ..., \beta_q) =$$

$$\left(\bigcup_{\flat_{\bullet_{\varphi(i)}} \in \mho_{\flat_{\bullet_i}}, \kappa_{\varphi(i)} \in \kappa} \sqrt[3]{1 - \prod_{i=1}^{q} \left(1 - \left(\flat'_{\varphi(i)}\right)^3\right)^{\Lambda}} / \prod_{i=1}^{q} \kappa'_{\varphi(i)}, \bigcup_{\zeta_{\varphi(i)} \in \nu_{\flat_{\bullet_i}}, \kappa^{\bullet}_{\varphi(i)} \in \kappa^{\bullet}} \prod_{i=1}^{q} \left(\zeta'_{\varphi(i)}\right)^{\Lambda} / \prod_{i=1}^{q} (\kappa^{\bullet})'_{\varphi(i)} \right).$$

Step 3: Let, the result holds for $\ell = q + 1$.

$$\oplus_{i=1}^{q} \Lambda_i \aleph_{\varphi(i)} \oplus \Lambda_{q+1} \aleph_{q+1} =$$

$$\left(\bigcup_{\flat_{\bullet_{\varphi(i)}} \in \mho_{\flat_{\bullet_i}}, \kappa_{\varphi(i)} \in \kappa} \sqrt[3]{1 - \prod_{i=1}^{q} \left(1 - \left(\flat'_{\varphi(i)}\right)^3\right)^{\Lambda}} / \prod_{i=1}^{q} \kappa'_{\varphi(i)}, \bigcup_{\zeta_{\varphi(i)} \in \nu_{\flat_{\bullet_i}}, \kappa^{\bullet}_{\varphi(i)} \in \kappa^{\bullet}} \prod_{i=1}^{q} \left(\zeta'_{\varphi(i)}\right)^{\Lambda} / \prod_{i=1}^{q} (\kappa^{\bullet})'_{\varphi(i)} \right) \oplus$$
$$\left(\bigcup_{\flat_{\bullet_{\varphi(q+1)}} \in \mho_{\flat_{\bullet_{q+1}}}, \kappa_{\varphi(q+1)} \in \kappa} \sqrt[3]{1 - \left(1 - \left(\flat'_{\varphi(q+1)}\right)^3\right)^{\Lambda_{q+1}}} / \kappa'_{\varphi(q+1)}, \bigcup_{\zeta_{\varphi(q+1)} \in \nu_{\flat_{\bullet_{q+1}}}, \kappa^{\bullet}_{\varphi(q+1)} \in \kappa^{\bullet}} \left(\zeta'_{\varphi(q+1)}\right)^{\Lambda_2} / (\kappa^{\bullet})'_{\varphi(q+1)} \right).$$

$$= \left(\bigcup_{\flat_{\bullet_{\varphi(i)}} \in \mho_{\flat_{\bullet_i}}, \kappa_{\varphi(i)} \in \kappa} \sqrt[3]{1 - \prod_{i=1}^{q+1} \left(1 - \left(\flat'_{\varphi(i)}\right)^3\right)^{\Lambda}} / \prod_{i=1}^{q+1} \kappa'_{\varphi(i)}, \bigcup_{\zeta_{\varphi(i)} \in \nu_{\flat_{\bullet_i}}, \kappa^{\bullet}_{\varphi(i)} \in \kappa^{\bullet}} \prod_{i=1}^{q+1} \left(\zeta'_{\varphi(i)}\right)^{\Lambda} / \prod_{i=1}^{q+1} (\kappa^{\bullet})'_{\varphi(i)} \right).$$

Thus, we can say that

$$FePHHWA(\beta_1, \beta_2, ..., \beta_\ell) =$$

$$\left(\bigcup_{\flat_{\bullet_{\varphi(i)}} \in \mho_{\flat_{\bullet_i}}, \kappa_{\varphi(i)} \in \kappa} \sqrt[3]{1 - \prod_{i=1}^{\ell} \left(1 - \left(\flat'_{\varphi(i)}\right)^3\right)^{\Lambda}} / \prod_{i=1}^{\ell} \kappa'_{\varphi(i)}, \bigcup_{\zeta_{\varphi(i)} \in \nu_{\flat_{\bullet_i}}, \kappa^{\bullet}_{\varphi(i)} \in \kappa^{\bullet}} \prod_{i=1}^{\ell} \left(\zeta'_{\varphi(i)}\right)^{\Lambda} / \prod_{i=1}^{\ell} (\kappa^{\bullet})'_{\varphi(i)} \right).$$

Hence proved. □

Assume $\beta_i = \left(\mho_{\flat_{\bullet_i}}/\kappa_i, \nu_{\flat_{\bullet_i}}/\kappa^{\bullet}_i\right)(i = 1, 2, ..., \ell)$ be any collection of FePHFNs and Fermatean Probabilistic Hesitant Fuzzy Hybrid Weighted Geometric (FePHFWG):FePHFN$\ell \to$ FePHFN. Then the FePHFHWG operator is given as:

$$\begin{aligned} FePHHWG(\beta_1, \beta_2, ..., \beta_\ell) &= \Lambda_1 \aleph_1 \otimes \Lambda_2 \aleph_2 \otimes .... \otimes \Lambda_\ell \beta_\ell. \\ &= \prod_{i=1}^{\ell} \Lambda_i \aleph_{\varphi(i)}. \end{aligned} \tag{11}$$

Here, $\Lambda = (\Lambda_1, \Lambda_2, ..., \Lambda_\ell)$ are the weights and $\Lambda_i \geq 0, \sum_{i=1}^{\ell} \Lambda_i = 1$. Also $\varphi(i)$ is the permutation as $(\varphi(1), \varphi(2), ..., \varphi(k))$. Assume $\beta_i = \left(\mho_{\flat_{\bullet_i}}/\kappa_i, \nu_{\flat_{\bullet_i}}/\kappa^{\bullet}_i\right)(i = 1, 2, ..., \ell)$ be any collection of FePHFNs. Then, the aggregation result obtained by using FePHFHWG is as follows:

FePHHWG$(\beta_1, \beta_2, ..., \beta_\ell) =$

$$\left\{ \bigcup_{\flat_{\varphi(i)} \in \mho_{\flat_{\bullet_i}}, \kappa_{\varphi(i)} \in \kappa} \prod_{i=1}^{\ell} \left(\flat'_{\varphi(i)}\right)^{\Lambda} / \prod_{i=1}^{\ell} \kappa'_{\varphi(i)}, \bigcup_{\zeta_{\varphi(i)} \in \nu_{\flat_{\bullet_i}}, \kappa^{\bullet}_{\varphi(i)} \in \kappa^{\bullet}} \sqrt[3]{1 - \prod_{i=1}^{\ell} \left(1 - \left(\zeta'_{\varphi(i)}\right)^3\right)^{\Lambda}} / \prod_{i=1}^{\ell} (\kappa^{\bullet})'_{\varphi(i)} \right\}. \tag{12}$$

Proof: The proof is straight forward. □

Building a Comprehensive Decision Matrix Integrating (FePHFS). In order to handle inherent ambiguity, we investigate in this section how FePHFS may be integrated with a MADM approach. Choosing the best solutions with consideration is necessary to achieve the best results. In this endeavor, algorithms are essential since they function as instruments for methodical decision-making. In this sense, an algorithm is a systematic series of well considered procedures intended to produce the optimal solution for a given issue. In this stage, we provide a highly-complex method that uses FePHFS Information. A collection of α alternatives, indicated as $\Bbbk = \Bbbk_1, \Bbbk_2, ..., \Bbbk_\alpha$, and λ criteria, denoted as $\top = \top_1, \top_2, ..., \top_\beta$, are taken into consideration by this algorithm. The decision matrix $\Gamma = [\gimel_{\pounds\lambda}]_{\alpha\times\beta}$ is constructed from these components taken together. The algorithmic approach provides a structured technique to resolve uncertainty inside the FePHFS framework, enabling decision-makers to navigate complicated choice scenarios with a methodical tool. The relative relevance of these traits is indicated by the weight vectors $\Lambda_h = \{\Lambda_1, \Lambda_2, ..., \Lambda_\lambda\}$.

Algorithm

Step 1: Initiate the analysis with a decision matrix $\Gamma = [\gimel_{\pounds\lambda}]_{\alpha\times\beta}$ encompassing alternatives ($\Bbbk_\pounds$) and associated criteria ($\top_\lambda$), each assigned with specific weightings (Λ_λ).

$$\Gamma = [\gimel_{\pounds\lambda}]_{\alpha\times\beta} \begin{pmatrix} \left(\mho_{\flat_{\cdot_{11}}}/\kappa_{11}, \nu_{\flat_{\cdot_{11}}}/\kappa^{\bullet}_{11}\right) & \left(\mho_{\flat_{\cdot_{12}}}/\kappa_{12}, \nu_{\flat_{\cdot_{12}}}/\kappa^{\bullet}_{12}\right) & . & . & \left(\mho_{\flat_{\cdot_{1\lambda}}}/\kappa_{1\lambda}, \nu_{\flat_{\cdot_{1\lambda}}}/\kappa^{\bullet}_{1\lambda}\right) \\ \left(\mho_{\flat_{\cdot_{21}}}/\kappa_{21}, \nu_{\flat_{\cdot_{21}}}/\kappa^{\bullet}_{21}\right) & \left(\mho_{\flat_{\cdot_{22}}}/\kappa_{22}, \nu_{\flat_{\cdot_{22}}}/\kappa^{\bullet}_{22}\right) & . & . & \left(\mho_{\flat_{\cdot_{2\lambda}}}/\kappa_{2\lambda}, \nu_{\flat_{\cdot_{2\lambda}}}/\kappa^{\bullet}_{2\lambda}\right) \\ . & . & . & . & . \\ . & . & . & . & . \\ \left(\mho_{\flat_{\cdot_{\pounds 1}}}/\kappa_{\pounds 1}, \nu_{\flat_{\cdot_{\pounds 1}}}/\kappa^{\bullet}_{\pounds 1}\right) & \left(\mho_{\flat_{\cdot_{\pounds 2}}}/\kappa_{\pounds 2}, \nu_{\flat_{\cdot_{\pounds 2}}}/\kappa^{\bullet}_{\pounds 2}\right) & . & . & \left(\mho_{\flat_{\cdot_{\pounds\lambda}}}/\kappa_{\pounds\lambda}, \nu_{\flat_{\cdot_{\pounds\lambda}}}/\kappa^{\bullet}_{\pounds\lambda}\right) \end{pmatrix}$$

Step 2: Proceed by normalizing the data, especially for attributes related to costs.

$$\Gamma^{\clubsuit} = \begin{cases} \gimel_{\pounds\lambda}, & \text{if } \textit{Benefit Attribute}, \\ \gimel^{c}_{\pounds\lambda}, & \text{if } \textit{Cost Attribute}, \end{cases}$$

where $\gimel_{\pounds\lambda} = \left(\mho_{\flat_{\cdot_{\pounds\lambda}}}/\kappa_{\pounds\lambda}, \nu_{\flat_{\cdot_{\pounds\lambda}}}/\kappa^{\bullet}_{\pounds\lambda}\right)$ and $\gimel^{c}_{\pounds\lambda} = \left(\nu_{\flat_{\cdot_{\pounds\lambda}}}/\kappa^{\bullet}_{\pounds\lambda}, \mho_{\flat_{\cdot_{\pounds\lambda}}}/\kappa_{\pounds\lambda}\right)$.

Step 3: Use the scoring, and first fine the hybrid matrix and apply the FePHHWA operator.

Step 4: Utilizing the hybrid matrix apply the FePHHWG operator.

Step 5: Determine the score for both the proposed operators and rank them in descending order.

4|Case Study

Due to the constantly changing risks to passenger safety, airport security screening procedures must be optimized in today's air travel environment. Effective screening is required because there must be a balance between maintaining strict security protocols and enabling smooth passenger movement. This improvement is important for improving security regulations as well as preventing long screening processes from possibly disrupting air travel. Airports may enhance their overall operating efficiency, decrease delays, and pptimized screening procedure.

Whrovide a great passenger experience by implementing a simplified and oen tackling the intricacies of enhancing airport security screening, decision-making becomes a crucial instrument. Due to the complexity of security issues, wise and calculated choices must be made in order to strike an efficient balance between security precautions and the requirement for quick passenger processing. Making decisions is the foundation for introducing cutting-edge technology to improve the accuracy and efficacy of security protocols, such as sophisticated screening apparatus and data analytics. In addition, choices on staffing levels, resource distribution, and the use of intelligent technology are crucial to reaching airport security screening process optimization. In the end, decision-making serves as the primary tool for formulating and carrying out plans that support security while simultaneously preserving the efficiency of air transport operations.
Let's explore various options of smart technologies to optimize machines in a manufacturing facility.

(1) **Advanced Imaging Technology (AIT) Scanners** ($\Bbbk_1$)**:** Scanners using AIT are a major improvement in airport security checks. These scanners use state-of-the-art technology, such backscatter or millimeter-wave X-rays, to provide detailed pictures of travelers' bodies that protect delicate anatomical information. By spotting hidden hazards that conventional metal detectors might overlook, AIT scanners improve security and provide a non-intrusive yet reliable way to guarantee passenger safety.

(2) **Queue Management Systems**($\Bbbk_2$)**:** In order to maximize customer service and operational effectiveness across a variety of businesses, queue management systems are essential. Through the automation and coordination of human movement, these systems reduce wait times, improve customer satisfaction, and provide a more seamless service encounter. Queue Management Systems (QMS) facilitate informed decision-making, effective resource allocation, and ongoing customer queuing process improvement for organizations by means of real-time data analysis.

(3) **Pre-Screening Programs**($\Bbbk_4$)**:**Pre-screening systems are essential for maximizing airport security because they use cutting-edge technologies and risk-assessment techniques to find travelers who pose little threat, enabling quicker processing. Travelers benefit from these initiatives' increased operational effectiveness, shorter wait times, and more efficient use of security resources, all of which make for a more seamless and convenient airport experience.

(4) **Automated Security Lanes** ($\Bbbk_4$)**:** Automated security lanes are the modern approach to airport security that use technology to expedite the screening procedure. These lanes use cutting-edge technology, such biometric identification and automated scanners, to increase productivity while upholding strict security regulations. In addition to increasing passenger flow, automated security lane deployment is a prime example of a calculated investment in utilizing automation to address the changing needs of contemporary aviation security.

Consider some specific criterions for earthquake response over given alternatives.

(1) **Wait Time Reduction**(T_1)**:** Cutting wait times is a critical need for streamlining airport security screening procedures in order to improve both operational effectiveness and customer experience. Reducing wait times considerably is mostly dependent on making decisions about staffing, technology, and resource allocation that are efficient.

(2) **Security Effectiveness** (T_2)**:** The capacity of security measures to identify and prevent possible attacks while reducing vulnerabilities is measured by their security effectiveness. In order to provide a strong and all-encompassing protection against a variety of security threats, it entails the strategic deployment of technologies and processes.

(3) **Passenger Experience**(T_3)**:** Improving the passenger experience is essential to highlighting how important it is to give passengers a pleasant and effective travel experience. To improve passenger pleasure throughout their time at the airport, this entails streamlining procedures, cutting down on wait times, and offering facilities.

Step 1: Let's consider a FePHF information matrix 1, where we have four alternatives $\Bbbk = \{\Bbbk_1, \Bbbk_2, \Bbbk_3, \Bbbk_4\}$ and three criteria $\mathsf{T} = \{\mathsf{T}_1, \mathsf{T}_2, \mathsf{T}_3\}$ as mentioned in Table 1, each assigned with specific weightings $\Lambda_1 = 0.314, \Lambda_2 = 0.355, \Lambda_3 = 0.331$.

	T_1	T_1	T_3
$\Bbbk_1$	$\left(0.2/0.6, 0.3/0.4\right)(0.3/1)$	$(0.45/1)\left(0.2/0.6, 0.8/0.4\right)$	$\left(0.7/0.9, 0.6/0.1\right)\left(0.6/0.7, 0.7/0.3\right)$
$\Bbbk_2$	$\left(0.8/0.3, 0.1/0.7\right)(0.1/1)$	$(0.5/1)\left(0.3/0.7, 0.4/0.3\right)$	$(0.9/0.1)\left(0.3/0.6, 0.2/0.4\right)$
$\Bbbk_3$	$\left(0.05/0.5, 0.2/0.5\right)(0.1/1)$	$(0.1/1)\left(0.3/0.4, 0.4/0.6\right)$	$\left(0.5/0.5, 0.6/0.5\right)\left(0.3/0.9, 0.1/0.1\right)$
$\Bbbk_4$	$\left(0.4/0.4, 0.6/0.6\right)(0.5/1)$	$(0.7/1)\left(0.1/0.5, 0.1/0.5\right)$	$(0.2/0.1)\left(0.3/0.2, 0.6/0.8\right)$

TABLE 1. FePHF Information Matrix.

Step 2: Given that there are no cost requirements at play, normalization can be skipped in this situation.

Step 3: Utilize the Table 1 first we find the hybrid values using hybrid weighted average operator. The hybrid matrix is given in Table 2. Then, we apply the hybrid weighted averaging aggregation operator with new weights $\Lambda_1 = 0.415, \Lambda_2 = 0.238, \Lambda_3 = 0.311$.

	T_1	T_2	T_3
$\Bbbk_1$	$(0.459/1)\left(0.180/0.6, 0.788/0.4\right)$	$\left(0.699/0.9, 0.599/0.1\right)\left(0.602/0.7, 0.702/0.3\right)$	$\left(0.196/0.6, 0.294/0.4\right)(0.322/1)$
$\Bbbk_2$	$(0.899/0.1)\left(0.303/0.6, 0.202/0.4\right)$	$(0.510/1)\left(0.277/0.7, 0.377/0.3\right)$	$\left(0.789/0.3, 0.098/0.7\right)(0.114/1)$
$\Bbbk_3$	$\left(0.499/0.5, 0.599/0.5\right)\left(0.303/0.9, 0.102/0.1\right)$	$\left(0.049/0.5, 0.196/0.5\right)(0.114/1)$	$(0.102/1)\left(0.277/0.4, 0.377/0.6\right)$
$\Bbbk_4$	$(0.712/1)\left(0.086/0.5, 0.086/0.5\right)$	$(0.2/0.1)\left(0.303/0.2, 0.602/0.8\right)$	$\left(0.392/0.4, 0.589/0.6\right)(0.521/1)$

TABLE 2. Hybrid Values for Weighted Averaging.

Step 4: Utilize the Table 1 first we find the hybrid values using hybrid weighted average operator. The hybrid matrix is given in Table 3. Then, we apply the hybrid weighted averaging aggregation operator with new weights $\Lambda_1 = 0.415, \Lambda_2 = 0.238, \Lambda_3 = 0.311$.

	T_1	T_2	T_3
$\Bbbk_1$	$(0.427/1)\left(0.204/0.6, 0.811/0.4\right)$	$\left(0.702/0.9, 0.602/0.1\right)\left(0.599/0.7, 0.699/0.3\right)$	$\left(0.220/0.6, 0.322/0.4\right)(0.294/1)$
$\Bbbk_2$	$(0.901/0.1)\left(0.299/0.6, 0.200/0.4\right)$	$(0.478/1)\left(0.306/0.7, 0.408/0.3\right)$	$\left(0.810/0.3, 0.114/0.7\right)(0.098/1)$
$\Bbbk_3$	$\left(0.502/0.5, 0.602/0.5\right)\left(0.299/0.9, 0.1/0.1\right)$	$\left(0.059/0.5, 0.220/0.5\right)(0.098/1)$	$(0.086/1)\left(0.306/0.4, 0.408/0.6\right)$
$\Bbbk_4$	$(0.684/1)\left(0.102/0.5, 0.102/0.5\right)$	$(0.202/0.1)\left(0.299/0.2, 0.599/0.8\right)$	$\left(0.422/0.4, 0.618/0.6\right)(0.491/1)$

TABLE 3. Hybrid Values for Weighted Geometric.

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Step 5: Determine the score as given in Table 4.

FePHHWA	FEPHHWG
0.0011	-0.0013
0.0612	0.0163
0.0010	-0.0003
0.0278	0.0120

Table 4. Score Values.

The ranking for the proposed hybrid aggregation operations is given as:

$$FePHHWA : \Bbbk_2 > \Bbbk_4 > \Bbbk_1 > \Bbbk_3$$

$$FePHHWG : \Bbbk_2 > \Bbbk_4 > \Bbbk_3 > \Bbbk_1$$

Thus, $\Bbbk_2$ is the best choice. The results can be visualized through figure 1.

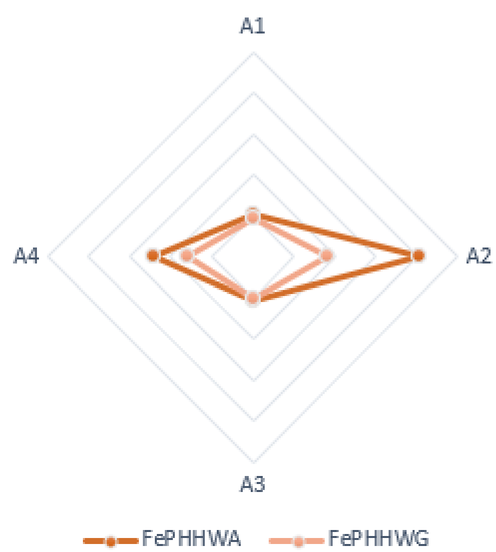

Figure 1: Scoring of FePHHWA & FePHHWG

5|Conclusion

To sum up, this study presents a novel strategy for improving airport security screening procedures by incorporating Fermatean Probabilistic Hesitant Fuzzy Sets and algebraic operations into decision-making. The research highlights the critical function of decision-making in response planning and the importance of aggregation operators in formulating winning tactics. Based on a combination of algebraic operations, the recently suggested Fermatean Probabilistic Hesitant Fuzzy Set hybrid aggregation operators known as FePHHWA and FePHHWG offer a viable path forward for MADM development. The adaptability and effectiveness of the methodology are clearly illustrated by means of a comprehensive numerical case study, offering not only a palpable enhancement in airport security screening but also a solid basis for managing uncertainties related to the incorporation of smart technologies in airport facilities and decision-making procedures.

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